AD 631 475

# SUMMARY OF FINAL REPORT

# VENTILATION TESTS OF FALLOUT SHELTER SPACES IN NEW YORK CITY AND VICINITY

FEBRUARY 1966

"This report has been reviewed by the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense."

SRI Subcontract No. B-64212(4949A-3)-US
Work Unit 1214B

"Distribution of this document is unlimited."

GUY B. PANERO, INC.
Consulting Engineers
468 Park Avenue South, New York, N.Y. 10016



Summary Prepared by:
Guy B. Panero, Inc.
February 1966

In order to ascertain the physical environmental capabilities of typical fallout shelter spaces in the various climatic regions, a series of experimental studies has been undertaken for the Office of Civil Defense. The major objectives of these studies are to:

(a) evaluate parameters determining the physical environment in identified shelters or other space having shelter potential;

(b) determine minimum equipment requirements for environmental control; and

(c) gather and correlate experimental data in support of computational methods or for direct use as empirical information.

This report summarizes the portion of the effort undertaken by the Special Projects Staff of Guy B. Panero Inc.

This effort consisted of a series of natural and forced ventilation tests conducted at eight distinct shelter facilities, in New York City and vicinity, during the winter of 1963-64 and the summer of 1964.

An estimated 80 per cent of the identified shelter spaces in New York City are located above ground, and the summer experimental work concentrated on this type of shelter area. Tests were conducted in the inner corridor (core) shelter areas of three high-rise buildings and of two public schools. In addition, basement tests were performed in these two schools and in a large suburban home. Ventilation tests were also conducted in an inexpensive underground community shelter, built by a group of rural families.

Winter tests were performed in a privately-owned underground shelter with an efficient heat sink to investigate the lower limits of shelter habitability during winter weather.

A number of inexpensive ventilation and heat dissipation devices were built and tested for their ability to improve shelter habitability. These included directional punkahs, manual valve-type air pumps and water-cooled heat exchangers.

Shelter occupancy was simulated using aggregate electromechanical "Simocs," and measurements of the resulting shelter environment were recorded using psychrometers, anemometers, copper-constantan thermocouples and thermometers. O.C.D. Test Vehicle #3 was also used to deliver preconditioned air during the forced ventilation tests in the school basement shelter areas.

Analysis and evaluation of the data obtained during the experimental program suggests that the following conclusions may be drawn:

A. Core Areas Within Above-Ground Buildings

(1) With an occupancy load of one person/10 sq.ft. of floor area, natural ventilation (crosswind via open windows and updraft via vertical shafts) air will maintain a shelter effective temperature below 85°F with outside air conditions at the New York City 15 percentile summer design level*--except during periods of unusually calm wind.

(2) During the summer months the shelter should be considered as adiabatic. Low boundary heat losses mean that ventilating air is the only vehicle effective in disposing of heat generated in the shelter.

(3) Of the formulas given in the ASHRAE Guide** for predicting natural ventilation, that used for cross ventilation gives values reasonably in accord with experimental results. The formula for predicting updraft does not agree with experimental results; it appears to be unsatisfactory for determining shelter ventilation when updraft is used.

(4) The most effective method of inducing natural ventilation is to use crosswind ventilation on all floors containing shelters, augmented by updraft on the lower floors only.

(5) Closed shelter operation under summer conditions is not possible for more than a few hours. However, operation with shelter doors open and all outside building openings closed may produce a tolerable environment for periods up to a day or longer.

B. Buried and Semi-Buried Shelters

(1) With high ventilation rates (6-10 cfm/occupant) the shelter heat sink plays a minor role in dissipating heat, and hence soil conductivity has little effect on shelter environment under these conditions. With low ventilation rates soil conductivity becomes an important factor in heat dissipation.

(2) In shelters with high resistance to natural ventilation (i.e. shelters which have small intake and exhaust openings; or high

---

*This is the combination of wet and dry bulb temperatures, calculated independently, which would be exceeded during 15 per cent of the hours in the four summer months of June through September. In a normal summer there should be approximately 450 hours at or above the 15 percentile design level, which for New York City is 80°F DB-72°F WB.

**The American Society of Heating, Ventilating and Air Conditioning Engineers Guide and Data Book, 1963, Chapter 24.

internal resistance; or one opening serving as both intake and exhaust) a shelter load of one person/10 sq.ft. of floor area will cause the effective temperature to exceed 85°F with outside air conditions at the 15 percentile summer design level. This will occur even if the shelter has good heat transfer characteristics.

(3) During typical winter weather in northeastern United States, undercrowded (less than one person/10 sq.ft. of floor area) underground shelters with an efficient heat sink may create habitability problems for shelter occupants because of low (40°F-50°F) effective temperatures--even with minimum ventilation rates. Application of thermal insulation with radiant reflection characteristics to the shelter surfaces can substantially increase (10°F-15°F) the shelter effective temperature and also preserve the shelter heat sink for further use.

C. <u>Manual Ventilation Devices</u>

Preliminary tests indicate that directional punkahs and valve-type piston pumps may be very attractive, from a cost-effectiveness standpoint, as a means to increase shelter ventilation and to avoid stagnant "hot spots." In addition, where well water is available, simple heat exchangers used in conjunction with such devices can remove a large percentage of the heat and moisture generated within the shelter.

Further experimental work is recommended to reduce costs of these manually operated devices, increase their durability, and improve effectiveness and ease of assembly.